Investigation into MoTe₂ based Dielectric Modulated AMFET Biosensor for Label-free detection of DNA including electric variational effects

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SUPPLEMENTARY FILE

1. Calibration

Fig. S0. The Calibration result of the models used in our simulation setup with the experimental result reported in [SR0].

Reference:

[SR0] J. Appenzeller, R. Martel, P. Avouris, J. Knoch, J. Scholvin, J.A. del Alamo, P. Rice and P. Solomon, “Sub-40 nm SOI V-groove n-MOSFETs,” IEEE Electron Device Lett. 23(2), 100–102 (2002).

2. Biosensor Performance For Detection of Neutral Biomolecules:

Fig. S1: (a) The Current vs Voltage Profile for detection of neutral biomolecules with dielectric constant varying from 1 to 10 at low drain voltage of 0.5V and grounded back-gate. The color bar at the top shows the dielectric constant of biomolecules under investigation. (b) The Current Sensitivity of

different dielectric constant. The maximum sensitivity increases with increase in dielectric constant of biomolecules. For dielectric constant of 10, the maximum current sensitivity is approximately 10^6 .

2. Dielectric Parameters considered for detection of Four stages of DNA Detection

TABLE S1

Stage No.	Cavity Condition	Dielectric Constant	Charge Density	Reference
1	Bare Device	1	0	-
2	ssDNA layer formation	2	$-1 \times 10^{11} \text{ C/cm}^2$	[SR1]
3	Partial Hybridized dsDNA	4	$-3 \times 10^{11} \text{ C/cm}^2$	[SR2,SR3]
4	Completely Hybridized dsDNA	8	$-5 \times 10^{11} \text{ C/cm}^2$	[SR2,SR3]

References:

[SR1] K. Tamersit, F. Djeflal, Carbon nanotube field-effect transistor with vacuum gate dielectric for label-free detection of DNA molecules: a computational investigation, IEEE Sensor. J. 19 (2019) 9263–9270, <https://doi.org/10.1109/JSEN.2019.2925597>.

[SR2] Ajay, R. Narang, M. Saxena, M. Gupta, Modeling and simulation investigation of sensitivity of symmetric split gate junctionless FET for biosensing application, IEEE Sensor. J. 17 (2017) 4853–4861, <https://doi.org/10.1109/JSEN.2017.2716102>.

[SR3] A. Cuervo, P.D. Dans, J.L. Carrascosa, M. Orozco, G. Gomila, L. Fumagalli, Direct measurement of the dielectric polarization properties of DNA, Proc. Natl. Acad. Sci. Unit. States Am. 111 (2014) E3624–E3630, <https://doi.org/10.1073/pnas.1405702111>.

3. Current Profile and Maximum Selectivity for Different Orientation Angles

Fig. S2 (a) Current-Voltage Characteristics for different orientational angles. The color bar at the top shows the angle of rotations of the DNAs. (b) Maximum Selectivity variation of Current for different orientation angles with respect to Horizontal Position (Square) and Vertical Position (Circle).

4. Impact of Gate Voltage:

a. Device Level Analysis:

Fig. S3. Current Voltage Characteristics for (a) Vertical Orientation (b) Horizontal Orientation for different back-gate biases. (b) Current Selectivity of vertical position with respect to Horizontal Position for different back-gate biases. The color bar at the top shows different back-gate biases. (d) Maximum Current Selectivity Variation with different back-gate biases.

Fig. S4. The Potential Profile for Horizontal and Vertical Position at back-gate bias of 1V. (Bottom) The electron Distribution in the channel in Horizontal and Vertical Condition for a back gate bias of 1V

b. Circuit Level Analysis:

Fig. S5. (a) Variation of the Voltage Transfer Characteristics for Horizontal (square) and Vertical (circle) orientations for different back-gate bias (b) Corresponding Output Voltage selectivity of Horizontal Position with respect to Vertical position.